NUI Galway
OÉ Gaillimh

Autumn Examinations 2012/ 2013

Exam Code(s)	4IF
Exam(s)	B.Sc. in Information Technology
Module Code(s)	CT420
Module(s)	Real-Time Systems
Paper No.	1
Repeat Paper	Y
External Examiner(s)	Prof. Michael O'Boyle
Internal Examiner(s)	Prof. Gerard Lyons
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Instructions: Answer 2 questions in section A and 2 questions in section B. All questions carry equal marks. Use separate Answer books for each section.

Duration	3 hours
No. of Pages	5
Discipline	Information Technology

Requirements:

MCQ
Handout
Statistical/ Log Tables
Cambridge Tables
Graph Paper
Log Graph Paper
Other Materials

Release to Library: Yes [X] [ ]

Section A

Q1

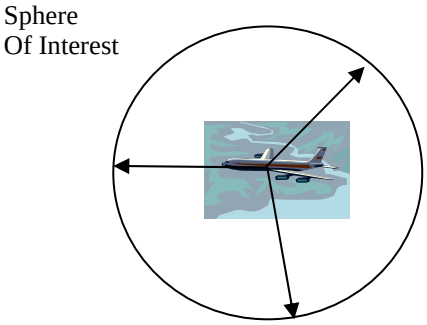
(i) TCAS (Traffic Collision Avoidance Systems) are fitted to commercial airplanes to minimise the risk of in-flight collisions caused by Air Traffic Control or pilot error. Essentially TCAS ensures that planes on a collision course will **automatically** communicate with and ultimately avoid each other.

Using this example, distinguish between, and give estimates for both the Sample Rate and Response Time of the TCAS system, and show how these terms are related. You can assume the following-

1. Max speed of both planes is 500 kilometres per hr.
2. It takes approximately 15 seconds for a plane to make the necessary physical position change.

Outline also, what size the 'Sphere of Interest' for the TCAS needs to be i.e. how far away planes need to be detected at in order to avoid a collision.

[10]



(ii) Compare and contrast the following time sources under the following headings; operation, cost, accuracy, availability

- Quartz crystal
- Oven Crystal
- GPS timing unit
- Atomic Clock

[15]

Explain how clock granularity can impact on the following-

- Fault diagnosis in a distributed system using timestamped log files
- Operating system responsiveness via timeslicing of processes

[10]

Q2

(i) Using each of the following examples, explain, using diagrams why time synchronisation is important and outline the level of synchronisation required:

- Electrical Power Line Fault Detection System
- Fault Logging System within a Power Plant
- Lip synchronisation (audio/video) across a WAN
- MMOG (Massively Multiplayer Online Gaming) Server servicing players from across the globe

[15]

(ii) Your company wishes to install its own NTP time server to service a range of its local LAN applications requiring synch levels better than 5 msec. You are asked to decide on the choice of remote NTP servers with which to configure your server.

- Explain the importance of the following criteria when selecting remote NTP servers
    - Stratum
    - Round Trip Delay & Jitter in network path to each server
    - Path Diversity
- Show how you would implement a test phase whereby you could assess the performance of various remote servers and the networks that connect them. Explain also how you would analyse the data and choose the best servers.

[20]

Q3

(i) Describe in some detail how Voice over IP (VoIP) operates. Your answer should consider the following:

- Voice codecs
- Role and importance of Transport layer protocols RTP & UDP, as well as RTCP
- Impact of codec choice, packet loss, M2E (Mouth to Ear) delay, and Jitter buffer design on quality
- Role of PLC (Packet Loss Concealment) and FEC (Forward Error Correction) techniques

[25]

(ii) What is meant by a Service Level Agreement (SLA)? Show and describe how DiffServ can be used to deliver & enforce QoS across Wide Area Networks.

[10]

Section B – Hard RTS

Q4

(i) What is meant by the Hamming distance of a set of code words? Use an example to illustrate your answer.

[5]

(ii) How can the Hamming (7, 4) code be used to encode 8-bit data? What error correcting and error detecting capabilities does the resulting encoding scheme have?

[10]

(iii) Using examples, discuss the cause and consequences of a stack overflow.

[10]

(iv) Using an example, show how graph-based bound calculations can be used to determine the worst-case execution time (WCET) of program code. Your example should include one loop and two if-then-else statements.

[10]

Q5

(i) Consider that you are a member of a development team responsible for the control software of an elevator. The software is controlled by a scheduler based on the cyclic executive approach. It controls 3 tasks with cycle times of 50 msec, 100 msec and 200 msec as shown in Table 1 below. The execution time of each task is well below its cycle time.

Task	Period (msec)	Exec Time (msec)
A	50	20
B	100	20
C	200	10

Table 1

(a) Using (pseudo and/or C) code, prototype a timer-interrupt-controlled cyclic executive for the above task schedule. Your answer must include an implementation of the timer-interrupt service routine.

[15]

(b) The elevator hardware creates asynchronous interrupts that are handled by the control software via interrupt service routines.
Use Table 1 to determine the task schedule and to calculate how much slack (e.g. unused CPU time) is available to process interrupt service routines.

[10]

(ii) How does static software redundancy using *N-version programming* work? Using examples distinguish between 2 voter types.

[10]

Q6

(i) Using the task set in Table 2 below:
- Calculate the overall *CPU utilisation U*.
- Determine the process schedule over the first 400 ms of task execution
    - using the *RM scheduling algorithm*.
    - using the *EDF scheduling algorithm*.

- Comment on the results of both schedules.

[15]

Task	Execution Time [ms]	Period [ms]
1	10	50
2	10	100
3	60	150
4	40	200

Table 2

ii) Briefly outline the role of POSIX in Operating System design.

[5]

iii) You are asked to develop a safety critical application that is required to run on a conventional Linux OS that supports many POSIX.4 features. Explain what POSIX.4 features you would use, how you would use them, commenting also on your choice of programming language.

[15]